

WHAT IS CLAIMED IS:

1. An energetic thermoplastic elastomer having A blocks and B blocks and being present in a substantially solid state suitable for use as a binder for at least one of a propellant, explosive, and gasifier, the energetic thermoplastic elastomer being formed from a composition comprising, as constituents:

A blocks terminated with isocyanate-reactive groups derived from monomers comprising one or more oxetane derivatives, the A blocks being crystalline at temperatures below about 75°C;

B blocks terminated with isocyanate-reactive groups derived from monomers comprising at least one member selected from the group consisting of oxirane and derivatives thereof, the B block(s) being amorphous at temperatures above about -20°C; and

linking groups derived from at least one diisocyanate and at least one linking compound comprising two functional groups which are reactive with isocyanate moieties of the diisocyanate.

2. An energetic thermoplastic elastomer as defined in claim 1, wherein:

the diisocyanate contains a first isocyanate moiety which is at least five times more reactive with the terminal groups of the blocks than a second isocyanate moiety thereof, whereby the more reactive first isocyanate moiety is capable of reacting with and end capping the terminal groups of the blocks, leaving the less reactive second isocyanate moiety free and unreacted; and

the linking compound has two isocyanate-reactive groups which are sufficiently sterically unhindered to be reactive with the free and unreacted second isocyanate moieties of the end-capped blocks.

3. An energetic thermoplastic elastomer as defined in claim 2, wherein the diisocyanate comprises toluene diisocyanate.

sub A²
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4. An energetic thermoplastic elastomer as defined in claim 1, wherein the A blocks are crystalline at temperatures below about 60°C.

5. An energetic thermoplastic elastomer as defined in claim 1, wherein the A blocks comprise homopolymers, copolymers, or terpolymers derived from one or more symmetrically-substituted oxetane monomers comprising at least one member selected from the group consisting of 3,3-bis(methylnitraminomethyl)oxetane and 3,3-bis(azidomethyl)oxetane.

sub A³
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6. An energetic thermoplastic elastomer as defined in claim 1, wherein the B block comprises a difunctional glycidyl azide polymer.

10 7. An energetic thermoplastic elastomer as defined in claim 1, wherein the B block comprises poly(glycidyl nitrate).

8. An energetic thermoplastic elastomer as defined in claim 1, wherein the thermoplastic elastomer has a weight average molecular weight of at least 40,000 and a number average molecular weight of at least 10,000.

15 9. An energetic thermoplastic elastomer as defined in claim 1, wherein the thermoplastic elastomer has a weight average molecular weight of at least 60,000 and a number average molecular weight of at least 12,000.

20 10. An energetic thermoplastic elastomer as defined in claim 1, wherein the thermoplastic elastomer has a weight average molecular weight of at least 80,000 and a number average molecular weight of at least 15,000.

11. An energetic thermoplastic elastomer as defined in claim 1, wherein a weight ratio of A to B blocks is between about 15:85 to about 40:60.

12. An energetic thermoplastic elastomer as defined in claim 1, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

13. An energetic thermoplastic elastomer of claim 1, wherein the isocyanate-reactive terminated groups of the B blocks are secondary hydroxyl groups.

14. A binder comprising:
about 50 wt% to about 95 wt% of at least one solid selected from the group
5 consisting of fuel material particulates and oxidizer particulates; and
at least one energetic thermoplastic elastomer having A blocks and B blocks
and being present in a substantially solid state to immobilize the particulates, the
energetic thermoplastic elastomer being formulated from a composition comprising,
as constituents:

10 A blocks terminated with isocyanate-reactive groups and derived from
monomers comprising one or more oxetane derivatives, the A blocks being crystalline
at temperatures below about 75°C;

B blocks terminated with isocyanate-reactive groups derived from
monomers comprising at least one member selected from the group consisting of
15 oxirane and derivatives thereof, the B blocks being amorphous at temperatures above
about -20°C; and

linking groups derived from at least one diisocyanate and at least one
linking compound.

15. A binder as defined in claim 14, wherein:
20 the diisocyanate contains a first isocyanate moiety which is substantially more
reactive with the terminal groups of the blocks than a second isocyanate moiety
thereof, whereby the more reactive first isocyanate moiety is capable of reacting with
and end capping the terminal groups of the blocks, leaving the less reactive second
isocyanate moiety free and unreacted; and

25 the linking compound has two isocyanate-reactive groups which are
sufficiently sterically unhindered to be reactive with the free and unreacted second
isocyanate moieties of the end-capped blocks.

16. A binder as defined in claim 14, wherein the A blocks are crystalline at temperatures below about 60°C.

17. A binder as defined in claim 14, wherein the A blocks comprise homopolymers, copolymers, or terpolymers derived from one or more symmetrically-substituted oxetane monomers comprising at least one member selected from the group consisting of 3,3-bis(methylnitraminomethyl)oxetane and 3,3-bis(azidomethyl)oxetane.

18. A binder as defined in claim 14, wherein the B block comprises a difunctional glycidyl azide polymer.

19. A binder as defined in claim 14, wherein the B block comprises poly(glycidyl nitrate).

20. A binder as defined in claim 14, wherein the isocyanate-reactive terminated groups of the B blocks are secondary hydroxyl groups.

21. A binder as defined in claim 14, wherein the solid comprises at least one member selected from the group consisting of aluminum, ammonium perchlorate, and ammonium nitrate.

22. A binder as defined in claim 14, further comprising at least one member selected from the group consisting of cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazatetracyclo[5.5.0.0^{5,9}.0^{3,11}]-dodecane (CL-20), and 4,10-dinitro-2,6,8,12-tetraoxa-4,10-diazatetracyclo[5.5.0.0^{5,9}.0^{3,11}]-dodecane (TEX).

23. A binder as defined in claim 14, further comprising at least one high energy plasticizer selected from the group consisting of nitroglycerine, butanetriol trinitrate (BTTN), alkyl nitratomethyl nitramines, trimethylolethane trinitrate

(TMETN), diethylene glycol dinitrate, triethylene glycol dinitrate, glycidyl azide polymer (GAP), and bis(dinitropropylacetal/-bis(dinitropropyl)formal (BDNPA/F).

24. A binder as defined in claim 14, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

5 25. A rocket motor propellant comprising the binder of claim 14.

26. A gun propellant comprising the binder of claims 14.

27. An explosive comprising the binder of claim 14.

28. A gasifier comprising the binder of claim 14.

29. A method of preparing an energetic thermoplastic elastomer having A
10 blocks which are crystalline at temperatures below about 75°C and the B blocks
which are amorphous at temperatures above about -20°C, the A blocks being
polyethers derived from monomers comprising oxetane derivatives, the B blocks
being polyethers derived from monomers comprising at least one member selected
from the group consisting of oxiranes and derivatives thereof, the method comprising:
15 providing A blocks and B blocks at approximately the stoichiometric ratios
that are intended to be present in the energetic thermoplastic elastomer, the A blocks
being terminated with isocyanate-reactive functional groups, derived from monomers
comprising oxetane derivatives, and crystalline at temperatures below about 75°C, the
B blocks being terminated with isocyanate-reactive functional groups, derived from
20 monomers comprising at least one member selected from the group consisting of
oxiranes and derivatives thereof, and amorphous at temperatures above about -20°C;
end-capping the A blocks and the B blocks by reacting the A blocks and B
blocks with at least one diisocyanate in which a least a first isocyanate moiety thereof
is substantially more reactive with the terminal groups of the blocks than a second
25 isocyanate moiety thereof, whereby the more reactive first isocyanate moiety is

capable of reacting with the terminal groups of the blocks, leaving the less reactive second isocyanate moiety free and unreacted; and

reacting the end-capped A blocks and the end-capped B blocks together with a linking compound having two isocyanate-reactive groups which are sufficiently unhindered to react with the free and unreacted second isocyanate moieties of the end-capped polymers.

30. A method as defined in claim 29, wherein the diisocyanate comprises toluene diisocyanate.

31. A method as defined in claim 29, wherein the A blocks are crystalline at temperatures below about 60°C.

32. A method as defined in claim 29, wherein the A blocks are homopolymers, copolymers, or terpolymers derived from one or more symmetrically-substituted oxetane monomers comprising at least one member selected from the group consisting of 3,3-bis(methylnitraminomethyl)oxetane and 3,3-bis(azidomethyl)oxetane.

33. A method as defined in claim 29, wherein the B block comprises a difunctional glycidyl azide polymer.

34. A method as defined in claim 29, wherein the B block comprises poly(glycidyl nitrate).

35. A method as defined in claim 29, wherein the thermoplastic elastomer has a weight average molecular weight of at least 40,000 and a number average molecular weight of at least 10,000.

36. A method as defined in claim 29, wherein the thermoplastic elastomer has a weight average molecular weight of at least 60,000 and a number average molecular weight of at least 12,000.

~~37. A method as defined in claim 29, wherein the thermoplastic elastomer has a weight average molecular weight of at least 80,000 and a number average molecular weight of at least 15,000.~~

38. A method as defined in claim 29, wherein a weight ratio of A to B
5 blocks is between about 15:85 to about 40:60.

39. A method as defined in claim 29, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

40. A method as defined in claim 29, wherein the isocyanate-reactive terminated groups of the B blocks are secondary hydroxyl groups.

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